AN ANALYSIS OF THE AQUATIC INVERTEBRATES AND HABITAT OF THE LOWER GALLATIN RIVER AND SOUTH COTTONWOOD CREEK

GALLATIN COUNTY, MONTANA

September 2001

A report to

Gallatin Local Water Quality District
Bozeman, Montana

by

Wease Bollman
Rhithron Biological Associates
Missoula, Montana

December, 2001

INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in September 2001 from seven sites on the lower Gallatin River and South Cottonwood Creek, Gallatin County, Montana. Aquatic invertebrate assemblages were sampled by personnel from the Gallatin Water Quality District. Study sites lie within the Montana Valley and Foothill Prairies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " …a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment…" (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "… an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valley and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled by Gallatin Water Quality District personnel from September 10 – 13, 2001. The purpose of the project is to provide an assessment for Total Maximum Daily Load development. Six sites on the lower Gallatin River and one site on South Cottonwood Creek were sampled. Two samples, considered replicates, were taken at each site. Site locations and sampling dates are indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998), consisting of a "traveling kicknet" method with one minute of effort applied for each replicate. In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with riffle/run prevalence.

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.
In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.
The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in the Gallatin River basin. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman

Table 1. Sampling sites and dates. Seven sites in the lower Gallatin River basin. September 10 – 13, 2001. 1998 and 2000.

Site designation	Site name	Sampling Dates	Location	GPS Latitude	GPS Longitude
LGALR 02	Highway 191	9/10/01	Lower Gallatin River: above Highway 191 bridge	45º 31' 11"	111º 15 ' 02"
LGALR 03	Williams	9/10/01	Lower Gallatin River: above Williams bridge	45º 32' 25"	111º 14 ' 04"
LGALR 06	Axtell	9/11/01	Lower Gallatin River: below Axtell bridge	45º 37' 24"	111º 12 ' 18"
LGALR 07	Shedd’s	9/11/01	Lower Gallatin River: above Shedd’s bridge	45º 40' 16"	111º 12 ' 31"
LGALR 10	CP	9/12/01	Lower Gallatin River: above Central Park	45º 49' 23"	111º 16 ' 20"
LGALR 13	Logan	9/12/01	Lower Gallatin River: above Logan bridge	45º 53' 09"	111º 26 ' 30"
SCTNC 01	S. Cott.	9/13/01	South Cottonwood Creek: at Trail bridge	45º 32' 04"	111º 04 ' 50"

1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.
6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

	Score			
metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included

in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).

- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the 7 sites visited. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

In general, habitat assessment scores diminished in a downstream direction on the lower Gallatin River. In the reach from the Highway 191 bridge downstream to the Axtell bridge site, habitat was judged optimal at each site. From Shedd's bridge downstream to Central Park, scores indicated sub-optimal habitat. At Logan bridge, marginal habitat was reported. From the Williams bridge downstream to the lowest site sampled on the Gallatin River, flow conditions were reported to be sub-optimal or marginal. At the South Cottonwood Creek site, habitat scores indicated optimal conditions.

At the Highway 191 bridge site, all instream and streambank parameters were judged optimal; however, the riparian zone width was perceived to be marginal on one side of the channel. Downstream, at the Williams bridge site, channel flow status was sub-optimal, and the bank along one side of the channel was perceived to be moderately unstable. All other instream, streambank, and riparian parameters were judged optimal at this site.

Marginal riffle development was reported at the site below Axtell bridge, and while substrate was perceived to be diverse, fine particles were present. Some new sediment deposition was noted. Sub-optimal flow conditions, consistent with the drought in 2001, were reported. The evaluator noted moderately stable streambanks at this site.

Above Shedd's bridge, riffle development was perceived to be reduced and was scored marginal. Sub-optimal benthic substrate diversity was reported, along with some embeddedness of larger benthic particles by fines. Some new sediment deposition was perceived as well. Rip-rap was reported, resulting in a poor rating for bank vegetative protection on one streambank. The riparian zone width was marginal along that same streambank. Channel flow status was judged marginal.

At the Central Park site, instream parameters were generally rated optimal, but a moderately unstable streambank was reported on one side of the channel. Vegetative protection was marginal and the riparian zone width was judged poor on this side. Flow status was perceived to be sub-optimal.

The site above Logan bridge received the lowest habitat assessment score of all sites studied; overall, habitat conditions here were rated marginal. Monotonous benthic substrates were reported, and embeddedness was judged severe. Moderate deposition of new sediments were noted. Rip-rap covered about ¼ mile of streambank in this area, resulting in diminished vegetative protection and moderate instability. The riparian zone width was judged marginal on both sides of the channel. Flow status at this site was perceived to be sub-optimal.

On South Cottonwood Creek, the visited site was reported to have optimal habitat conditions. All streambank and riparian parameters were rated optimal; however, flow status was judged sub-optimal. All other instream parameters were apparently unimpaired by human activities.

Figure 1. Total habitat assessment scores for six sites on the lower Gallatin River and one site on South Cottonwood Creek. September 2001.

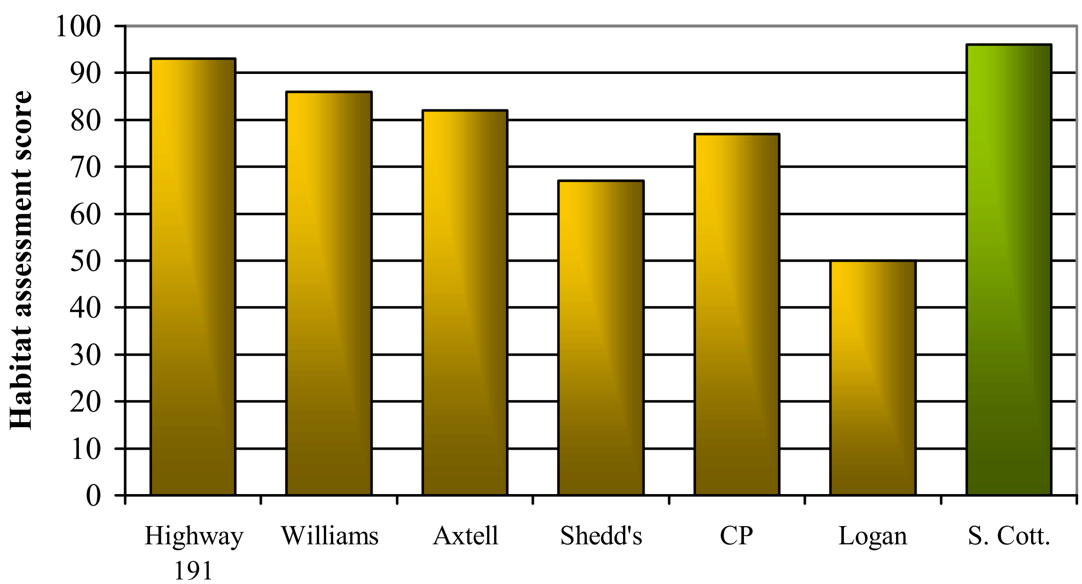


Table 4. Stream and riparian habitat assessment. Six sites on the lower Gallatin River and one site on South Cottonwood Creek. September 2001.

Max. possible score	**Parameter**	Highway 191	Williams	Axtell	Shedd's	Central Park	Logan	S. Cott.
10	Riffle development	10	10	5	5	8	4	10
10	Benthic substrate	9	9	8.5	8	9	4	10
20	Embeddedness	18	18	17	15.5	18	3	20
20	Channel alteration	20	19	16	15	20	13	19
20	Sediment deposition	20	18	15.5	15	16	8	20
20	Channel flow status	18	14	15	10	13	15	15
20	Bank stability: left / right	10 / 10	9 / 5	8 / 8	8 / 9	10 / 5	9 / 5	10 / 10
20	Bank vegetation: left / right	10 / 10	9 / 9	9 / 9	2 / 9	9 / 5	5 / 5	10 / 10
20	Vegetated zone: left / right	5 / 9	9 / 9	10 / 10	3 / 7	10 / 0	5 / 4	10 / 10
160	Total	149	138	131	106.5	123	80	154
	Percent of maximum	**93**	**86**	**82**	**67**	**77**	**50**	**96**
	CONDITION*	**OPT**	**OPT**	**OPT**	**SUB**	**SUB**	**MARG**	**OPT**

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1998.

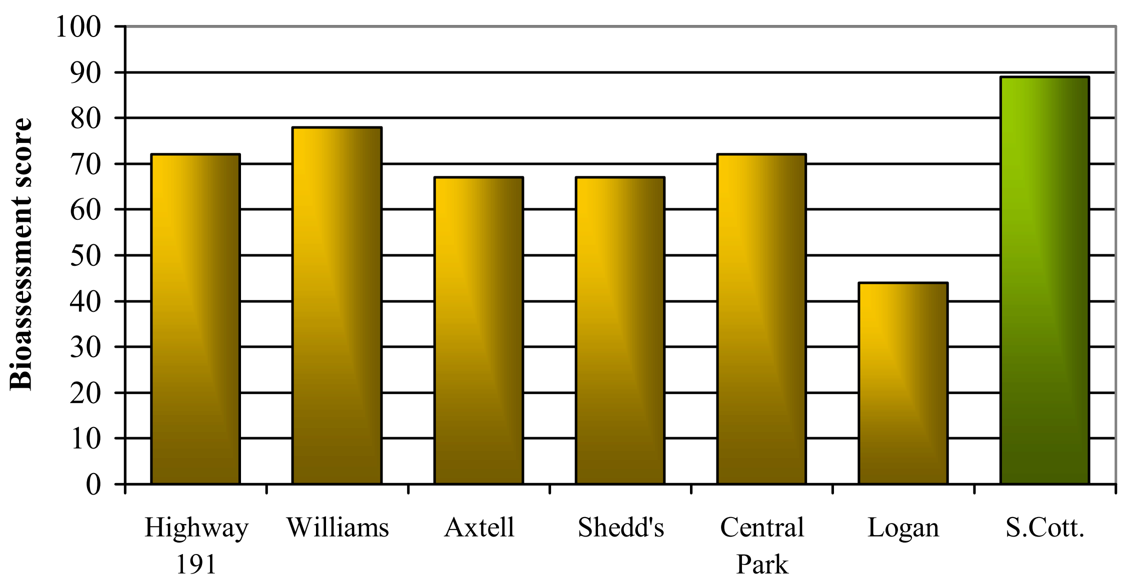
Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 7 sites in this study. Bars represent scores based on metric values averaged over 2 replicate samples taken at each site for all sites except for the Highway 191 site and the Williams bridge site, where replicate results were combined to create adequate sample sizes for the analysis. Table 5 itemizes each contributing metric and shows individual metric scores for each replicate. Tables 3a and 3b show criteria for impairment classifications and use-support categories recommended by Montana DEQ.

Low abundance of organisms in replicates complicated the evaluation of 2 of the sites in this study; conclusions and interpretation of results are tenuous for the site at the Highway 191 bridge and the site at Williams bridge. Each of the 4 replicates taken at these 2 sites contained fewer than 300 organisms. Whether the inadequacy of samples was due to depauperate communities at the sites or to sampling bias is not clear from the data. In order to produce more reliable bioassessment scores, results from replicates were combined. The resulting samples were somewhat larger than required for the analysis, thus bioassessments for these sites should be viewed cautiously. Richness metrics could be exaggerated, since twice the sampling effort was applied to achieve the results presented here. The uncertainty of scores and classifications for these sites is noted in Tables 4a and 4b.

When this bioassessment method is applied to these data, Gallatin River sites from the Highway 191 bridge to Central Park downstream, with the exception of the Williams bridge site, appear to be slightly impaired and partially supportive of their designated uses. At Williams bridge, scores suggest full support of designated uses despite slight impairment. At Logan bridge, the Gallatin River appears to be moderately

Figure 2. Total bioassessment scores for six sites on the lower Gallatin River and one site on South Cottonwood Creek, September, 2001. Total scores are based on average metric values for two replicate samples. Sites are described in Table 1.



impaired and partially supportive of designated uses. South Cottonwood Creek appears to be essentially unimpaired and fully supports its designated uses.

At the Highway 191 bridge, there were fewer Ephemeroptera taxa than expected. The proportions of both filter-feeders and tolerant taxa were greater than anticipated. At the Williams bridge site, all richness metrics gave results within expected limits but the proportions of filter-feeders and tolerant taxa were greater than expected for an unimpaired valley stream.

At the Axtell bridge and at Shedd's bridge, fewer Plecoptera taxa and fewer sensitive taxa than expected were present in samples. In addition, the proportions of filter-feeders and tolerant taxa were greater than expected at both locations. At Central Park, fewer Ephemeroptera taxa and fewer sensitive taxa were collected than anticipated. The Plecoptera taxa richness was also somewhat less than expected. The score calculated for the site at Logan bridge was the lowest among sites studied; there were somewhat fewer Ephemeroptera taxa in samples than expected, and the number of Plecoptera taxa was lower than anticipated. No sensitive taxa were present in samples taken at this site, and the proportion of tolerant taxa was much higher than predicted for an unimpaired valley system.

The score calculated for the site on South Cottonwood Creek was the highest among sites visited for this study. All richness metrics performed as well as expected for a stream essentially unimpaired by human disturbance. The average proportion of tolerant organisms in the replicate samples was somewhat higher than anticipated, however.

Aquatic invertebrate communities

Figure 3 is an ordination plot of the aquatic invertebrate communities collected in the samples from the Gallatin River and South Cottonwood Creek. Ordination is a graphical technique that results in an arrangement of the samples such that similar assemblages are closer together and dissimilar assemblages are farther apart. Similarity in this case is based on the taxa present and the relative abundance of each taxon in the sample. Such a plot is useful for illustrating the similarity of replicates taken at single sites and for comparing the similarity between replicates to the similarity of assemblages collected at different sites. The plot illustrates that replicated samples from any one site were generally similar to each other, but that communities sampled at Axtell, Shedd's, Central Park, and Logan were also very similar to each other. In fact, it appears that the between-site similarity is just as great as the between-replicate similarity for this group of sites. In contrast, though the between-replicate similarity is high for the South Cottonwood Creek samples, the assemblage sampled is quite different from that of any Gallatin River site. In addition, the Gallatin River sites at the Highway 191 bridge and at Williams bridge are very different not only from one another, but also from any other sites sampled.

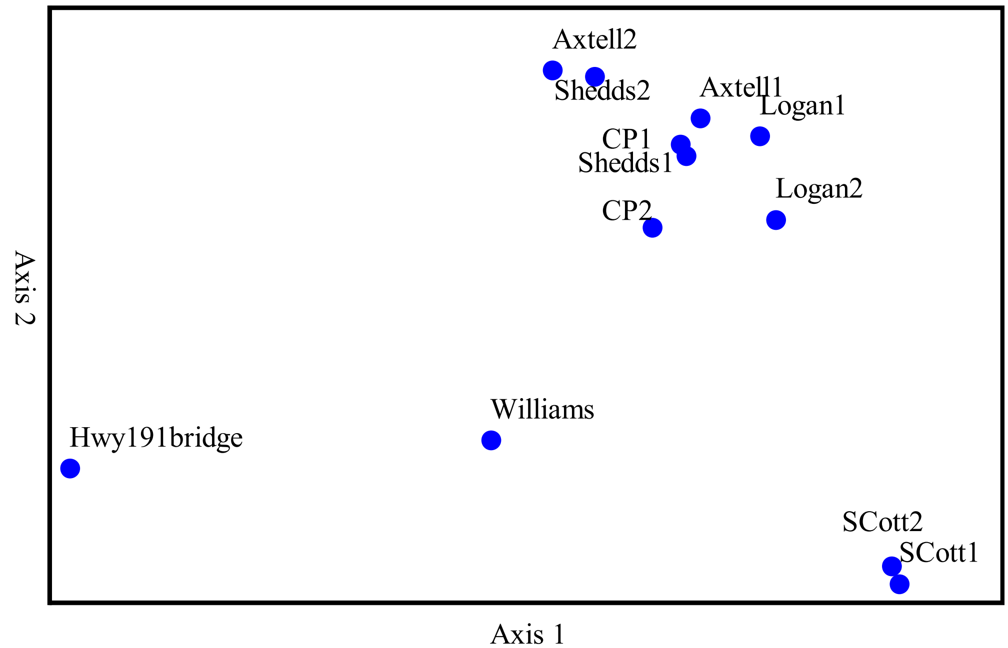
At the Highway 191 bridge, there was a low abundance of organisms in both replicate samples, so results were combined and metrics recalculated for the composited replicates. Whether the low abundance was due to actual conditions at the site or to sampling error is unclear from the data. Low abundance may indicate torrential flow conditions, recent disturbance of substrates, poor water quality due to the presence of toxins or anoxia, or other severe disturbances. Taxonomic composition of the assemblage

Table 5. Metric values, scores, and bioassessments for six sites on the lower Gallatin River and one site on South Cottonwood Creek. September 2001. Assessment classifications and use support designations in parentheses are tentative, since they are based on combined replicates, none of which contained adequate numbers of organisms for the analysis. Sites are described in Table 1.

	SITES											
	Highway 191	**Williams**	**Axtell**		**Shedd's**		**Central Park**		**Logan**		**S.Cottonwood**	
REPLICATE	Composited	Composited	1	2	1	2	1	2	1	2	1	2
METRICS	**METRIC VALUES**											
Ephemeroptera richness	5	7	6	5	6	8	2	3	4	5	11	8
Plecoptera richness	4	5	1	2	1	3	2	2	1	1	7	6
Trichoptera richness	5	7	7	5	5	4	5	5	6	5	9	7
Number of sensitive taxa	4	6	0	1	2	2	0	1	0	0	6	6
Percent filterers	12	19	2	15	10	17	5	4	14	2	1	1
Percent tolerant taxa	13	18	4	10	9	12	4	4	70	92	16	19
	METRIC SCORES											
Ephemeroptera richness	2	3	3	2	3	3	1	1	2	2	3	3
Plecoptera richness	3	3	1	2	1	2	2	2	1	1	3	3
Trichoptera richness	3	3	3	3	3	2	3	3	3	3	3	3
Number of sensitive taxa	3	3	0	1	2	2	0	1	0	0	3	3
Percent filterers	1	1	3	1	1	1	3	3	1	3	3	3
Percent tolerant taxa	1	1	3	2	2	1	3	3	0	0	1	1
TOTAL SCORE (max.=18)	13	14	13	11	12	11	12	13	7	9	16	16
PERCENT OF MAX.	**72**	**78**	**72**	**61**	**67**	**61**	**67**	**72**	**39**	**50**	**89**	**89**
Impairment classification*	**(PART)**	**(FULL)**	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**FULL**	**FULL**
USE SUPPORT †	**(SLI)**	**(SLI)**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**MOD**	**MOD**	**NON**	**NON**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3a. † Use support designations: See Table 3b.

Figure 3. Ordination plot (Principal Components Analysis) of assemblages in samples collected from the lower Gallatin River and South Cottonwood Creek sites, September 2001. In the plot, similar assemblages are near to one another and dissimilar assemblages are farther apart.



collected at this site seems to preclude any of these disastrous situations. The modified biotic index value (3.75) calculated for the assemblage suggests that water quality at the site was good, and probably consistent with the steady elevation of this value from upper Gallatin sites to lower Gallatin River areas documented in other studies (Bollman 2001). The elevation of the modified biotic index value longitudinally suggests increased nutrients, elevation of water temperatures, or both. The calculated value for the Highway 191 bridge site is within expectations for riverine systems in the Montana Valley and Foothill Prairies ecoregion. Another indicator of water quality is the number of mayfly taxa present at the site. Only 5 taxa were in evidence, somewhat fewer than expected despite the increased sampling effort, but they included the sensitive ephemerellids *Drunella doddsi* and *Drunella spinifera*. The elevated proportion of filter-feeding taxa at this site is probably consistent with the expectation of an increase in this functional group as montane conditions change to valley conditions. Four stonefly taxa were collected, including 2 species of the salmonfly *Pteronarcys* spp., suggesting that large-scale habitat features, such as streambank integrity and riparian function, were largely intact in this reach of the Gallatin. Good representation by caddisfly taxa, and a large number of "clinger" taxa suggest that sediment deposition did not impair the benthic community here. All expected functional components of the community were represented.

Water quality indicators gave somewhat better results at the Williams bridge site, where 7 mayfly taxa were collected. Although richness metrics such as the number of mayfly taxa may have been affected by the increased sampling effort, the modified biotic index value (3.37) also suggested water quality consistent with a riverine site. Sensitive taxa were plentiful; these included the caddisfly *Parapsyche elsis* and the stonefly *Doroneuria* sp. Nine predator taxa were present in the sample, suggesting abundant diverse habitats. The large number of "clinger" taxa (19) and the presence of 7 caddisfly taxa imply that fine sediments did not limit the availability of hard substrate surfaces to colonization. Large-scale habitat features appeared to be essentially intact; the presence of 5 stonefly taxa suggests this. The abundance of shredder taxa (19%) suggests ample riparian inputs of large organic material and flow conditions favorable for its retention. Filter-feeders and overall tolerant taxa were abundant, but did not overwhelm the sample and probably did not exceed the expectations for a riverine site. All expected functional components were represented in the sampled assemblage.

The assemblage sampled at Axtell bridge appears to be influenced somewhat by the flow contributed to the Gallatin River by South Cottonwood Creek, since the mean modified biotic index value (2.44) calculated for this site is quite low, suggesting an improvement in water quality compared to upstream sites. The effect appears to persist downstream of this site as well, since the biotic index value remains quite low at Shedd's and at the Central Park site. In addition, the proportions of both filter-feeders as well as tolerant taxa are considerably less at Axtell bridge than at either of the 2 Gallatin River sites upstream. Stonefly taxa richness falls off sharply at Axtell bridge, and remains low at all remaining downstream sites, suggesting that disturbance to large-scale habitat features, such as streambank integrity, riparian zone function, or channel morphology, may increase beginning at this site compared to upstream sites. Caddisfly taxa richness ($\mu = 6$) and "clinger" taxa richness ($\mu = 10.5$) suggest that sediment deposition does not appreciably limit benthic habitat availability. Functionally, the assemblage appears to be skewed toward shredders, which comprise 55% of the sampled assemblage. A single shredder taxon, *Lepidostoma* sp., overwhelmed one replicate and was very abundant in the other. This caddisfly is also the dominant taxon at the downstream sampling location at Central Park. Its dominance suggests ample inputs of large organic material from the riparian zone and flow conditions favoring retention of such material. Pools or other slow-flowing areas apparently contribute to the diversity of available habitats at these sites.

At Shedd's bridge, water quality indicators persist in performance suggestive of good water quality. The mean value for the modified biotic index (2.62) remained low at this site, and no fewer than 8 mayfly taxa were taken in samples. This site marks the appearance of two taxa suggestive of warming water temperatures; these are the caddisfly *Helicopsyche borealis* and snails in the family Physidae. Both animals are present at all remaining downstream sites. Cold-stenothermic taxa are limited to *Drunella spinifera*; in both replicates a total of 4 individuals in this taxon were taken. Only 2 stonefly taxa were present in replicates, suggesting disturbance to reach-scale habitat features may be present. The effects of fine sediment deposition appear to be minimal at this site; while "clinger" taxa richness is high ($\mu = 10.5$) and caddisfly taxa richness is only slightly lower than at upstream sites ($\mu = 4.5$), the mayfly fauna includes *Tricorythodes minutus*, and among the caddisflies, *H. borealis* and *Oecetis* sp. are other animals that prefer sediment-rich environs. All of these are present in low abundance, however. As at Axtell bridge, the functional composition of the assemblage is dominated by shredders, and once again, these are limited to a single taxon, the caddisfly *Lepidostoma* sp.

At Central Park, the mean modified biotic index value (2.15) suggests water quality unimpaired by nutrients, but the number of mayfly taxa taken in samples (3) suggests that other insults to water quality exist at this site. Evidence for elevated water temperatures can be found in the taxonomic composition of the sampled assemblage. Not a single cold-stenotherm was taken, and animals that prefer warm water were present. Both replicate samples were overwhelmed by the caddisfly *Lepidostoma* sp., skewing the functional composition of the assemblage toward shredders and suggesting that slow-moving water and/or pools allowed the retention of large organic contributions from riparian sources. The depauperate stonefly fauna suggests that reach-scale disturbances affected the benthic community at this site. Fine sediment deposition may have increased between Shedd's bridge and Central Park, since the number of "clinger" taxa ($\mu = 9$) was lower. Caddisfly taxa richness remains within expected limits for a valley stream, but the fauna includes 2 sediment-tolerant taxa, *Helicopsyche borealis* and *Oecetis* sp., suggesting that some sediment deposition may be present.

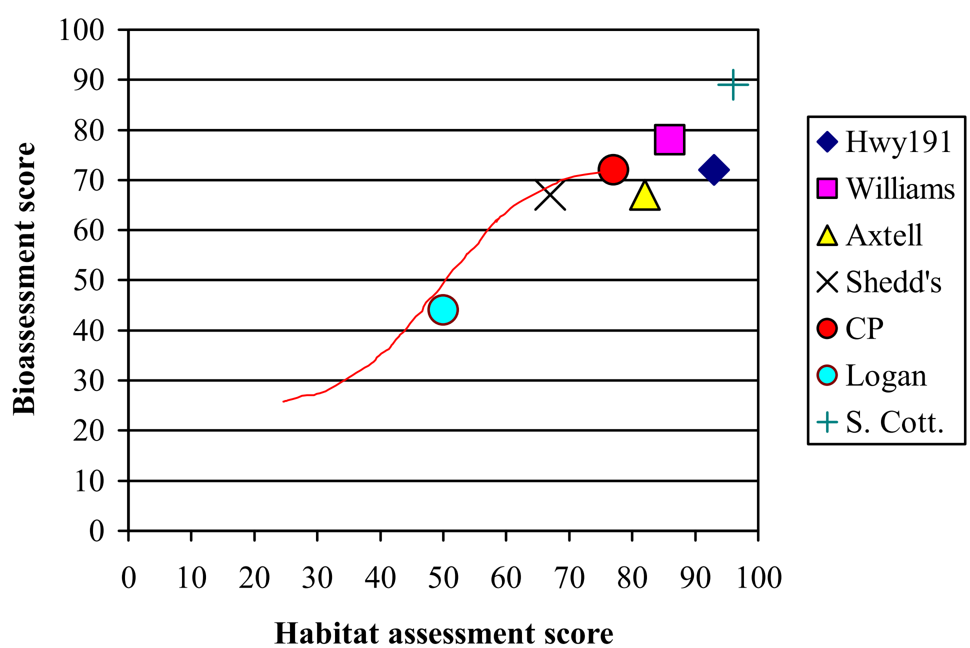
The assemblage sampled at Logan bridge scored the lowest among the sites included in this study. Water quality indicators suggested that nutrients and elevated water temperatures both contributed to impairment at this site. The modified biotic index value ($\mu = 6.20$) was considerably higher than at any other site, and much higher than expected for a valley stream. No cold-stenotherms were present, and the samples contained abundant taxa that prefer warm water, including the caddisflies *Cheumatopsyche* sp. and *Helicopsyche borealis*. No sensitive taxa were taken in either replicate sample, and tolerant taxa comprised a very large proportion ($\mu = 81\%$) of the assemblages. While mayfly taxa richness was not severely depressed, the fauna did include the tolerant *Tricorythodes minutus*. The stonefly fauna was limited to a single identifiable taxon, *Isogenoides* sp.; the poor representation of stoneflies suggests large-scale disturbance to streambanks, riparian zone, and/or channel morphology. Fine sediment deposition appears to have some impact on the benthic community, since "clinger" richness ($\mu = 9$) was somewhat lower than expected. As at Central Park, the caddisfly taxa richness did not fall below expectations, but once again the fauna included many sediment tolerant taxa, including *Helicopsyche borealis*, *Oecetis* sp., *Cheumatopsyche* sp., and *Neotrichia* sp. Riparian contributions of large organic material are not evident in the assemblage collected at this site. Lepidostoma sp. occurred only in low abundance here, and no other shredder taxon was evident. The dominant taxon at this site was *Helicopsyche borealis*, the dominance of which suggests nutrient-enriched warm water and the possibility of considerable sediment deposition. The high proportion of this caddisfly ($\mu = 52\%$) skews the functional composition of the assemblage toward scrapers, suggesting that riparian canopy is limited, and that ample nutrients promote algal films.

At the South Cottonwood Creek site, the benthic assemblage was characteristic of a valley or foothill stream essentially unimpaired by human disturbances. The low modified biotic index value ($\mu = 2.46$) as well as the diverse mayfly fauna (11 taxa in both replicates) suggests good water quality. Six sensitive taxa were present in each of the 2 replicates; among these were the cold-stenotherms *Caudatella* sp., *Drunella doddsi*, *Despaxia augusta*, and *Yoraperla* sp. Abundant stonefly taxa ($\mu = 6.5$) suggest that reach-scale habitat features were essentially intact. Fine sediment deposition appears to have no effect on biotic integrity, since caddisfly richness ($\mu = 8$) was high, and at least 18 "clinger" taxa were collected. A rich predator fauna was collected, implying the availability of abundant instream habitats. All expected functional components were present in appropriate abundances.

CONCLUSIONS

- Mildly impaired water quality appears to have a slight affect on benthic assemblages at the Highway 191 bridge and at the Williams bridge sites. Water quality impairments could be due to nutrient pollution, elevated water temperature, or both. It is possible, however, that these effects are entirely consistent with riverine conditions.
- Improvement in water quality indicators was evident at Axtell bridge and at the next two downstream sites, Shedd's bridge and Central Park. It is speculated that this may be due to the effects of the flow contributed by South Cottonwood Creek, which exhibits excellent water quality based on the indicators in the benthic community sampled there.
- There is some evidence for increased water temperatures at sites from Shedd's bridge downstream all the way to Logan, which was the most downstream site sampled.
- Assemblages from Axtell bridge, Shedd's bridge, and Central Park are dominated by a single shredder taxon, suggesting ample riparian inputs and flow and channel conditions conducive to retention of these inputs.
- Depauperate stonefly faunas from Axtell downstream all the way to Logan suggest that reach-scale disturbances may influence benthic assemblages in these reaches. Such disturbances may be related to streambank integrity, riparian zone function, or channel morphology.

Figure 4. The relationship of habitat assessment scores and bioassessment scores for sites on the Gallatin River and South Cottonwood Creek, September 2001. The red curve represents the hypothetical relationship between habitat scores and bioassessment scores if habitat quality solely determined biotic health.



- Low numbers of long-lived taxa were collected from every site visited, indicating that dewatering or other catastrophic interruptions to benthic life cycles have not recently affected biotic health in these reaches.
- Figure 4 compares total habitat scores with total bioassessment scores for the sites studied here. The red curve in the center of the graph represents the hypothetical relationship between habitat quality and biotic health when habitat degradation is the sole source of impairment to benthic assemblage health (Barbour and Stribling 1991). The cluster of data points in the upper right corner of the graph implies that those sites had good habitat conditions and good water quality. The site at Logan, however has lower bioassessment and habitat assessment scores. The position of its symbol is consistent with a situation where water quality is the primary limitation to biotic health.

LITERATURE CITED

Barbour, M.T., J.B. Stribling and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition. Pages 63-79 in W.S. Davis and T.P. Simon (editors) *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making.* Lewis Publishers, Boca Raton.

Barbour, M.T. and J.B. Stribling. 1991. Use of habitat assessment in evaluating the biological integrity of stream communities. In: *Biological Criteria: Research and Regulation.* Proceedings of a Symposium, 12-13 December 1990, Arlington, Virginia. EPA-440-5-91-005. U.S. Environmental Protection Agency, Washington, DC.

Bollman, W. 1998. Improving Stream Bioassessment Methods for the Montana Valleys and Foothill Prairies Ecoregion. Unpublished Master's Thesis. University of Montana. Missoula, Montana.

Bollman, W. 2001. An analysis of the aquatic invertebrates and habitat of the Gallatin River, August 2000. Report to the Montana Department of Environmental Qualtity, Helena, Montana. December 2001.

Bukantis, R. 1997. Rapid bioassessment macroinvertebrate protocols: Sampling and sample analysis SOP's. Working draft, April 22, 1997. Montana Department of Environmental Quality. Planning Prevention and Assistance Division. Helena, Montana.

Fore, L.S., J.R. Karr and L.L. Conquest. 1995. Statistical properties of an index of biological integrity used to evaluate water resources. *Canadian Journal of Fisheries and Aquatic Sciences*. 51: 1077-1087.

Fore, L.S., J.R. Karr and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. *Journal of the North American Benthological Society* 15(2): 212-231.

Gauch, H. G. 1982. *Multivariate Analysis in Community Ecology.* Cambridge University Press. Cambridge.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist.* 20: 31-39.

Hynes, H.B.N. 1970. *The Ecology of Running Waters.* The University of Toronto Press. Toronto.

Karr, J.R., and E. W. Chu. 1999. *Restoring Life in Running Water: better biological monitoring.*Island Press. Washington, DC.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound Lowland Streams, Washington, USA. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Omernik, J.M. 1997. Level III-Level IV ecoregions of Montana. Unpublished First Draft. August, 1997.

Patterson, A.J. 1996. The effect of recreation on biotic integrity of small streams in Grand Teton National Park. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M.Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA 440-4-89-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Rossano, E.M. 1995. Development of an index of biological integrity for Japanese streams (IBI-J). Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Wisseman, R.W. 1992. Montana rapid bioassessment protocols. Benthic invertebrate studies, 1990. Montana Reference Streams study. Report to the Montana Department of Environmental Quality. Water Quality Bureau. Helena, Montana.

Woods, A.J., Omernik, J. M. Nesser, J.A., Shelden, J., and Azevedo, S. H. 1999. Ecoregions of Montana. *(Poster)*. Reston, Virginia. USGS.

APPENDIX

Taxonomic data and summaries

The lower Gallatin River and South Cottonwood Creek

September 2001